Survival of Food Crops and Livestock in the Event of Nuclear War

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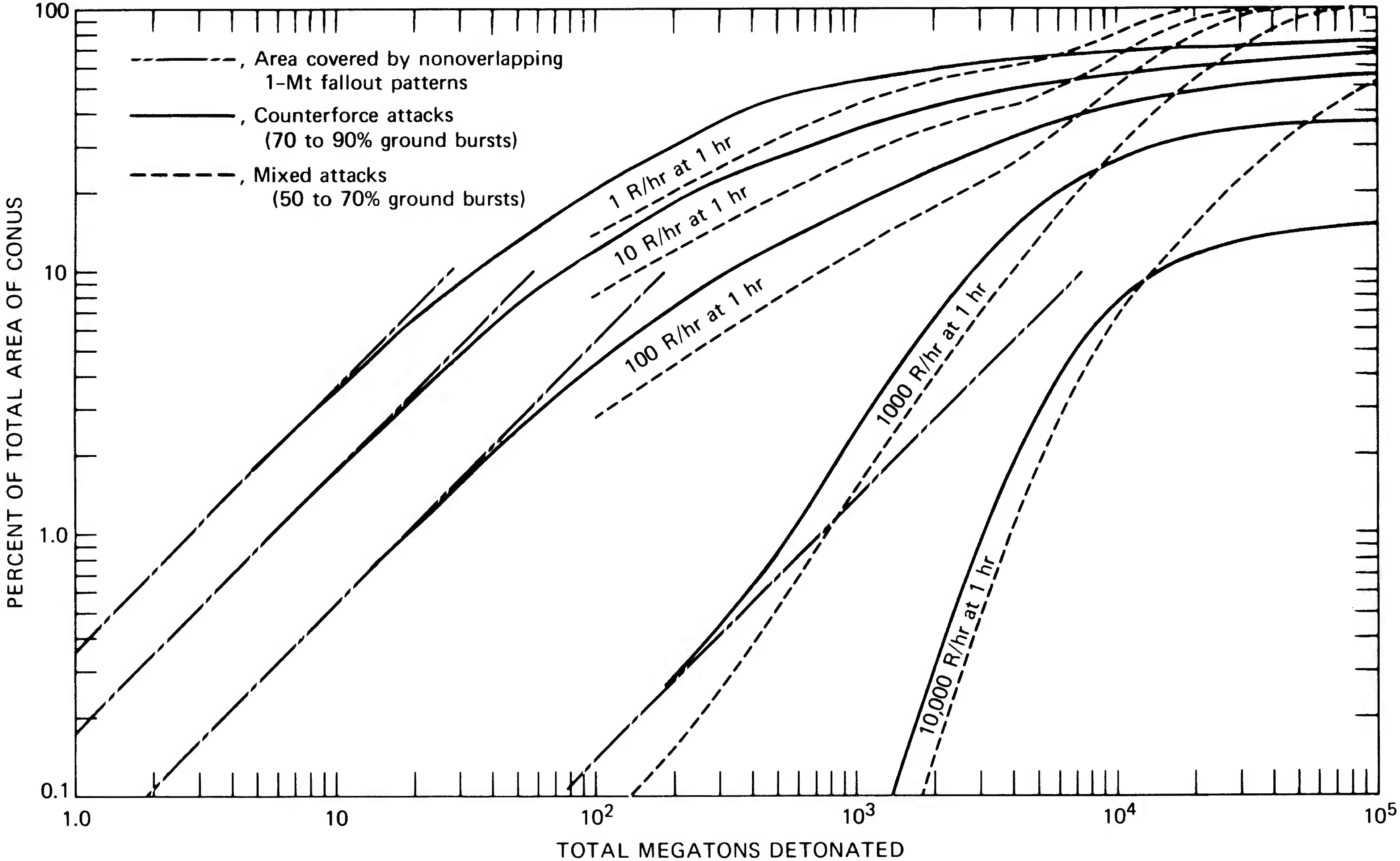

Fig. 1 Percent of area of the continental United States enclosed within selected I_S contours as a function of attack weight (50% fission weapons).

BETA-RADIATION DOSES FROM FALLOUT PARTICLES DEPOSITED ON THE SKIN

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ABSTRACT

Comparison of computed doses with the most recent experimental data relative to skin response to beta-energy deposition leads to the conclusion that, even for fallout arrival times as early as 10^3 sec (16.7 min postdetonation), no skin ulceration is expected from single particles 500 μ or less in diameter.

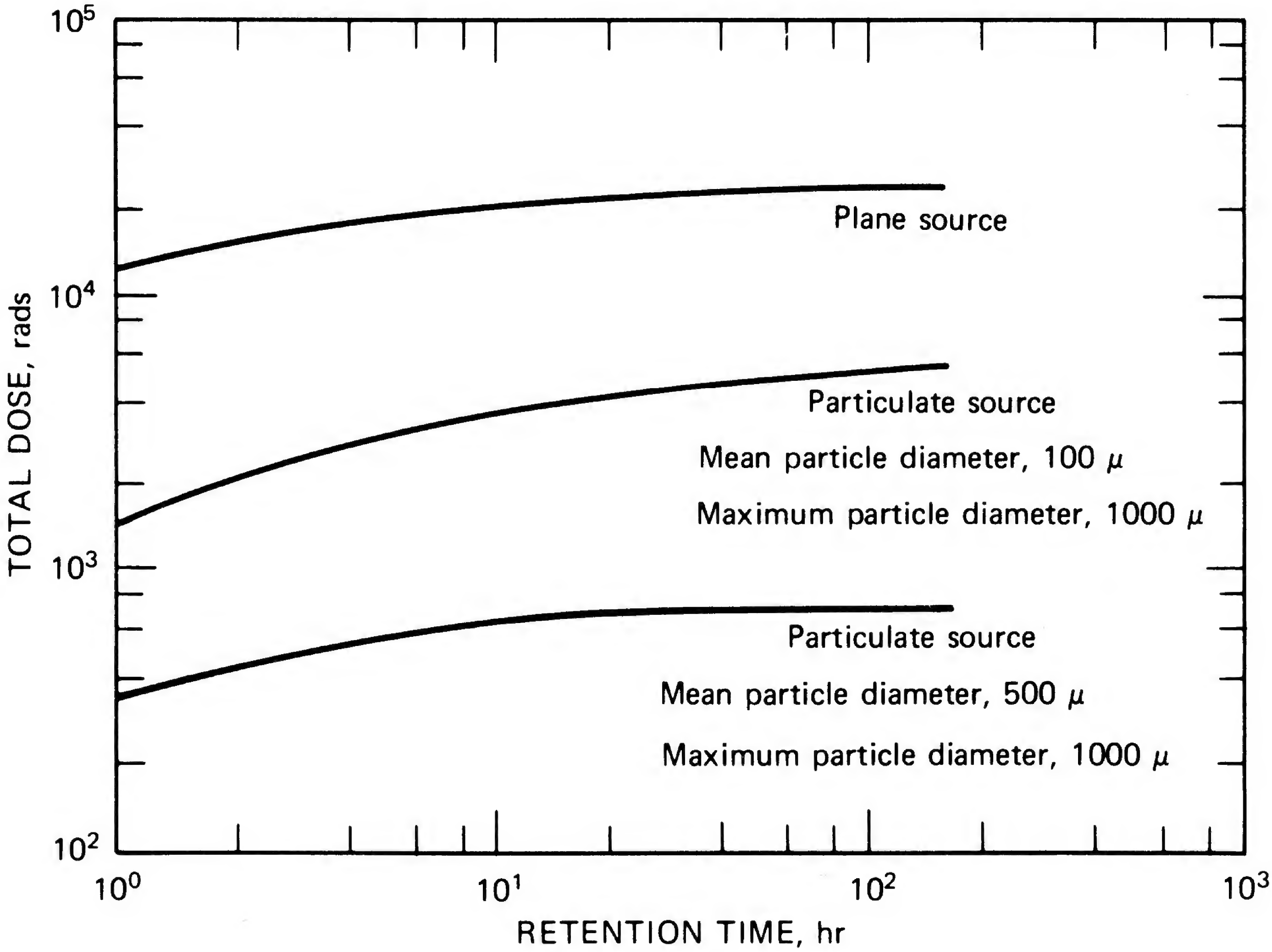


Fig. 6 Comparison between doses computed for a plane source and the corresponding values for a multiparticle source. Tissue depth, 100 μ; delay time, 10^3 sec; deposition density, 100 mg/sq ft; activity, 10^{15} fissions/cc.

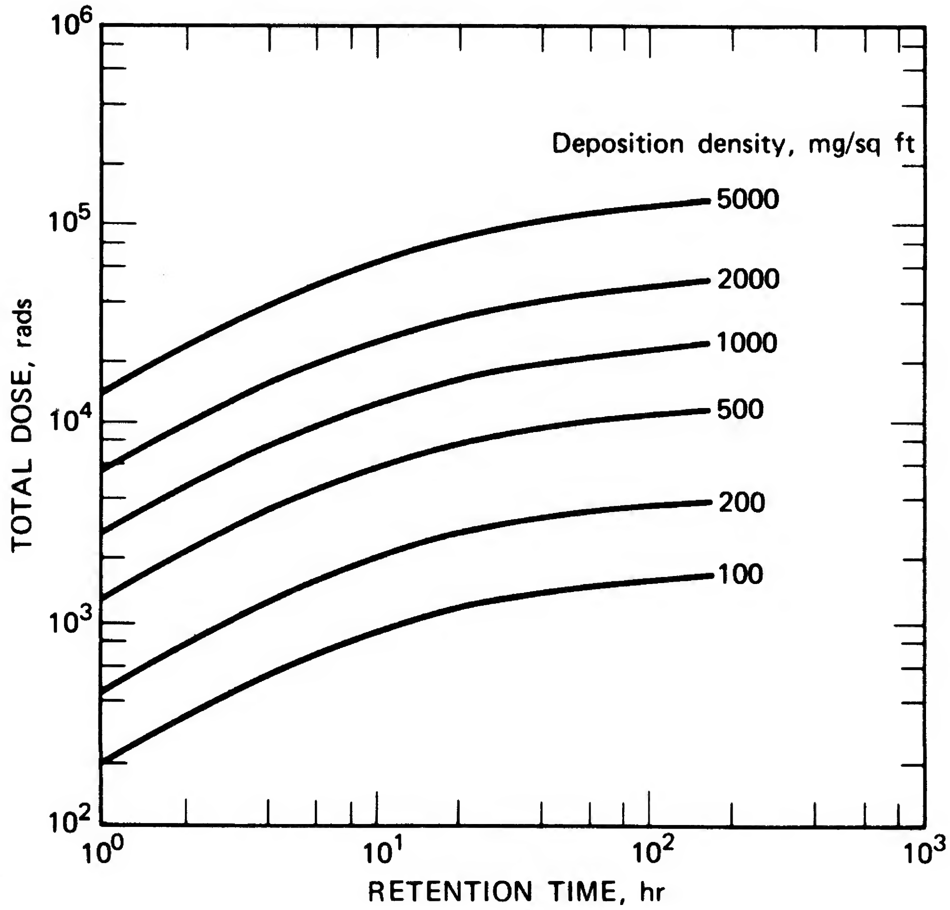


Fig. 13 Dose delivered to the skin by multiparticle fallout of 100-μ mean diameter and 1000-μ maximum diameter at an exposure starting time of 10^4 sec after detonation. Tissue depth, 100 μ.

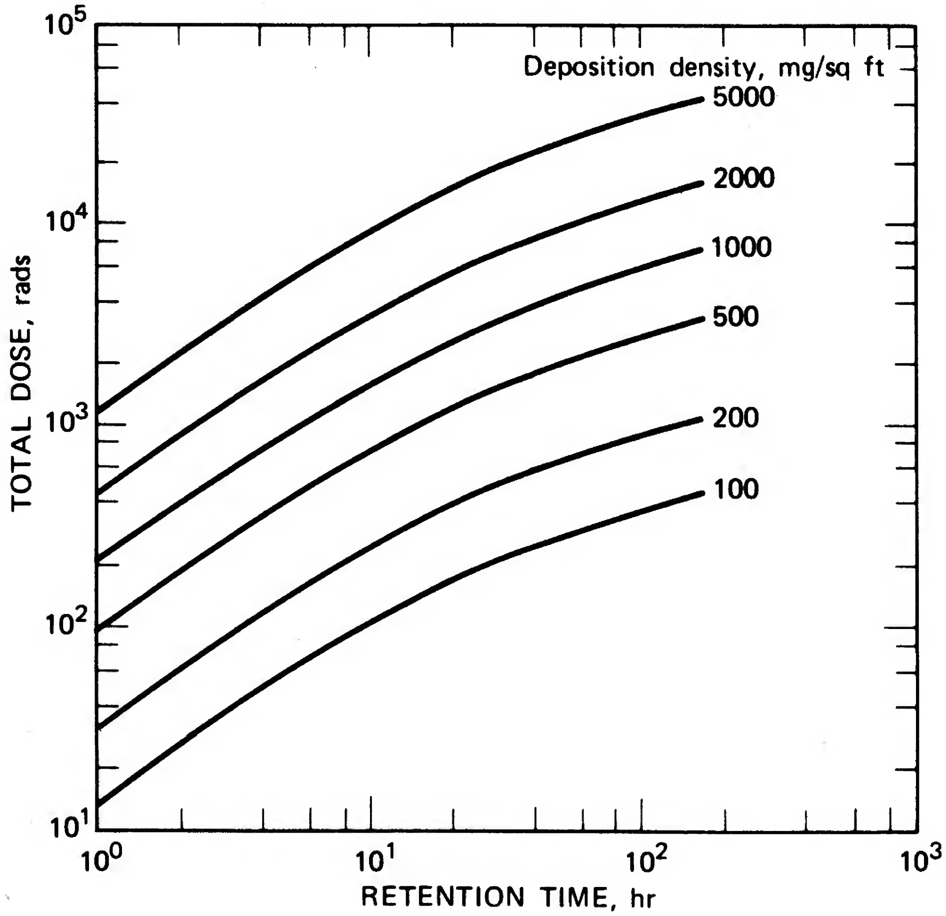
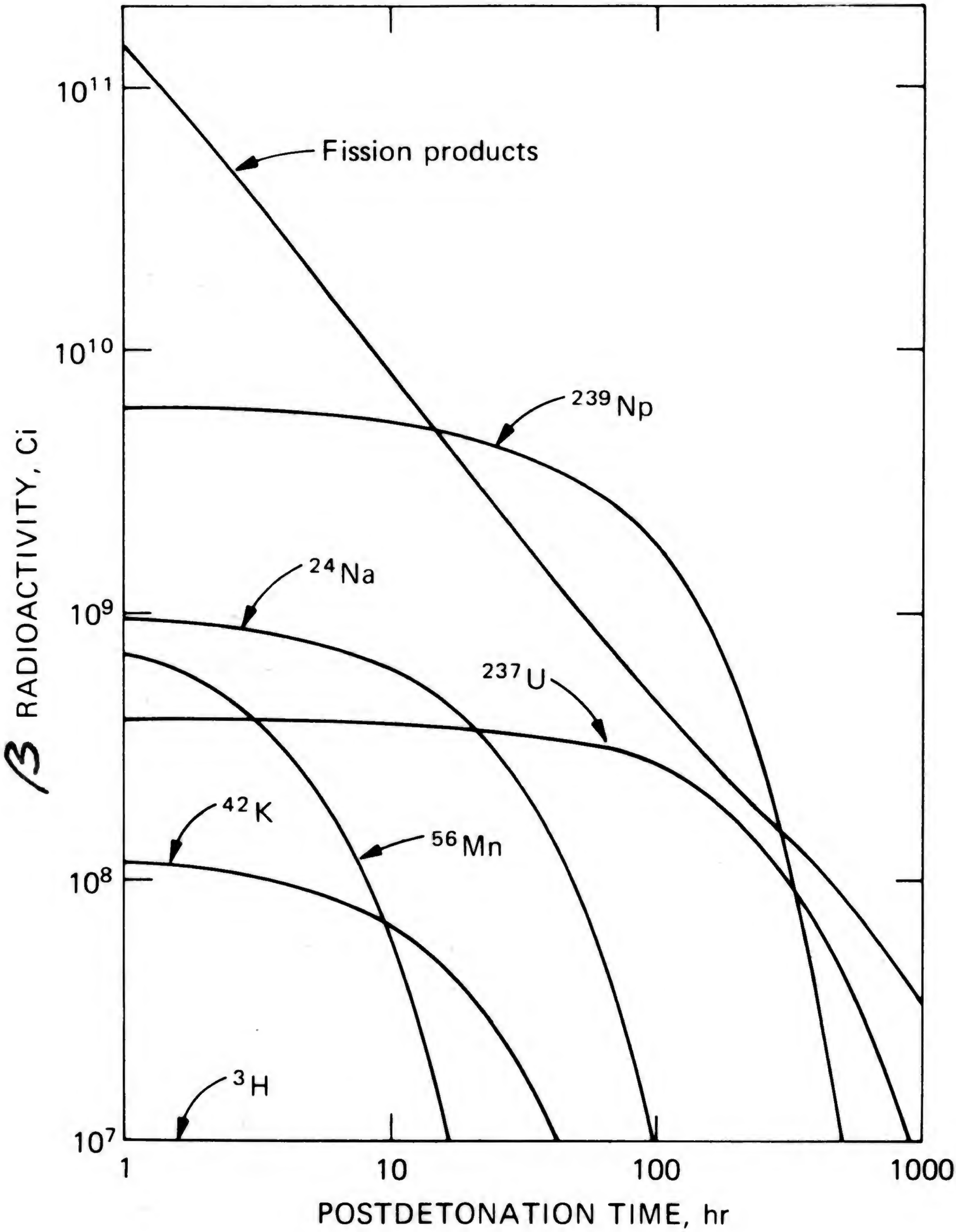


Fig. 14 Dose delivered to the skin by multiparticle fallout of 100-μ mean diameter and 1000-μ maximum diameter at an exposure starting time of 10^5 sec after detonation. Tissue depth, 100 μ.



Radioactivity from 1-Mt explosive with a fission-to-fusion ratio of 1.0.

RADIATION EFFECTS ON FARM ANIMALS: A REVIEW

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ABSTRACT

Hematopoietic death would predominate in food-producing animals exposed to gamma radiation under fallout conditions leaving animal survivors. Gamma-radiation doses of about 900 R would be lethal to 50% of poultry, and about half this level would be lethal for cattle, sheep, and swine. Grazing cattle and sheep would suffer most from combined radiation effects of skin-beta and ingested-beta radioactivity plus the whole-body gamma effects. The $LD_{50/60}$ for combined effects in ruminants is estimated to be at a gamma exposure of around 200 R in an area where the forage retention is 7 to 9%.

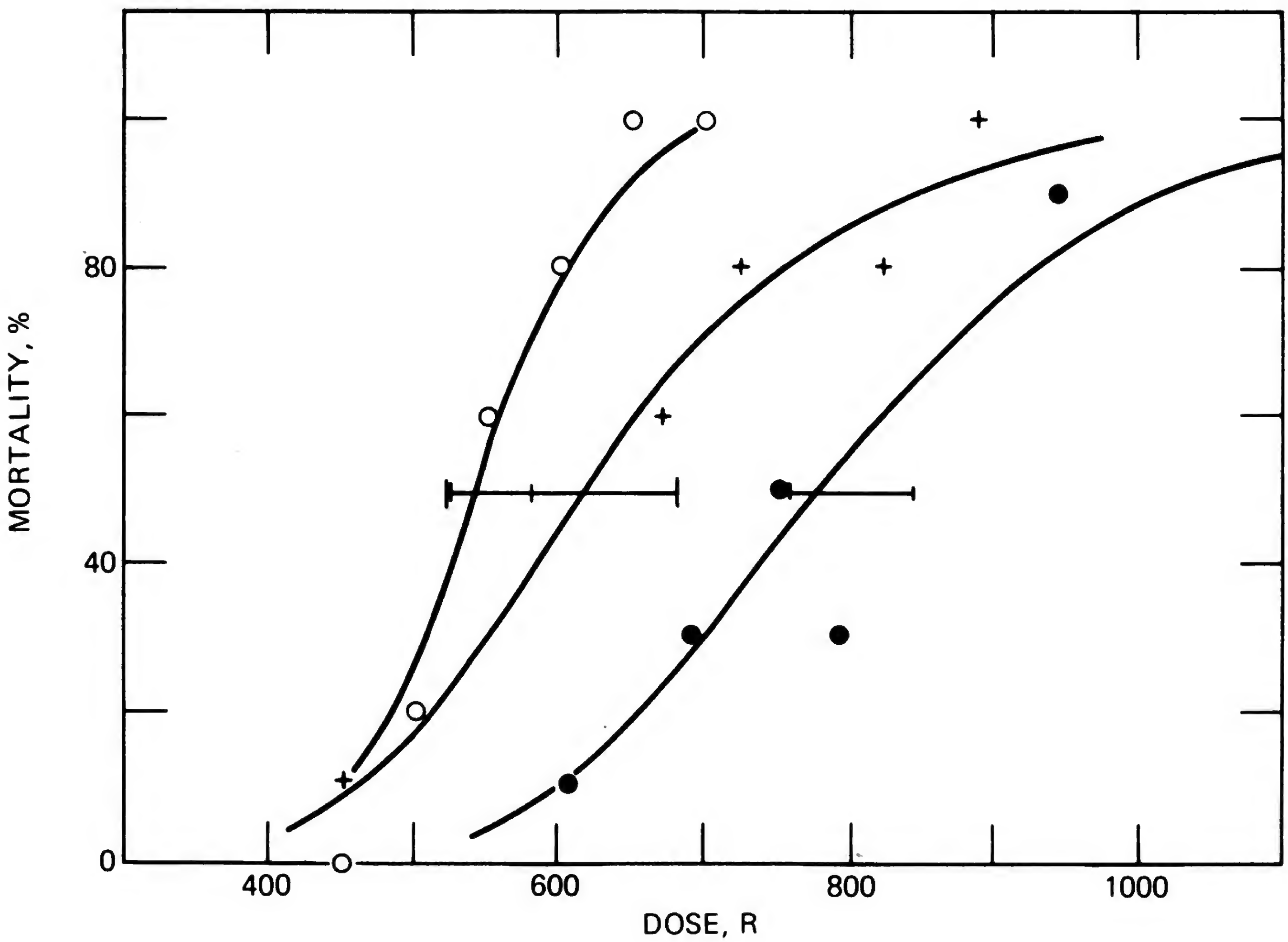

Fig. 1 Mortality of three species exposed to ^{60}Co at a dose rate between 0.5 and 1 R/min. ○, cattle; +, swine; •, burros; ⊢⊣, 95% confidence interval. (Data from D. G. Brown, UT–AEC Agricultural Research Laboratory.)

RADIATION DOSES TO VEGETATION FROM CLOSE-IN FALLOUT AT PROJECT SCHOONER

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Polyethylene sheets 6 m square and 6 mils thick were spread over as many *Artemisia* shrubs as could be covered conveniently at alternate stations along the arc.

The decrease to 52.6% in shrub doses is attributed to "self-shielding," which can be envisioned in terms of the masses of vegetation shadowing themselves. Shrubs that were protected from the direct fallout contamination showed even larger reductions in beta doses, however. For the stations shown in Table 1, the covered shrubs received only 31.2% of the beta dose at 25 cm in the open and away from shrubs.

Table 1

DOSE ACROSS THE MAIN FALLOUT PATTERN AT 25 CM ABOVE THE SOIL SURFACE AND TO SHRUBS

Station No.	Gamma-ray dose, rads: Dose at 25 cm	Gamma-ray dose, rads: Shrub Open*	Gamma-ray dose, rads: Shrub Covered	Beta-ray dose, rads: Dose at 25 cm	Beta-ray dose, rads: Shrub Open	Beta-ray dose, rads: Shrub Covered
12N	280		255	2100	1110	630
10N	380	420	350	3420	2160	1590
8N	800	810	770	7800	3000	2190
6N	950	1060	800	10650	5250	3000
4N	820		710	8640	4140	3270
2N	700	640	610	8100	3900	2100
0	650	680	470	7050	3000	2340
2	800	750	660	7500	2910	1770
4	650	660	480	5550	2250	1650
6	600	590	600	4650	2340	1650
8	720	700	600	5040	3240	2040
10	800	850	530	5400	3600	1560
12	620	580	550	4450	2190	900
14	440		370	3480	1620	900
16	300	‡	260		1650	570
18	200	210	200	2100	1500	540
20	130	120	80	1410	990	570
				Percent of 25-cm dose	52.6 ±10.9	31.2 ±6.9

SURVIVAL AND YIELD OF CROP PLANTS FOLLOWING BETA IRRADIATION

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ABSTRACT

Field experiments were carried out to investigate the effect of beta radiation on the growth of wheat, lettuce, and corn. The beta-radiation exposure was accomplished by fusing ^{90}Y onto 88- to 175-μ silica sand, and applying the sand to the crops with a remote-control applicator. Treatment levels on the wheat and lettuce crops ranged up to 59.4 mCi of ^{90}Y per square foot. In the corn experiment the highest level was 71.3 mCi of ^{90}Y per square foot. Wheat grain production was severely reduced when 6.6 mCi/sq ft of ^{90}Y was applied. This corresponds to approximately 2700 rads at the surface of the plant near the apical meristem. Lettuce yields were reduced significantly only at the highest treatment level, 59.4 mCi/sq ft, which corresponds to 9300 rads at the plant surface near the apical meristem. Some abnormalities could be seen on the lettuce at the 6.6 mCi/sq ft treatment level. Corn yield was not reduced and plant appearance was not changed in any of the treatments. The apical meristem of the corn plant was protected by about 1 cm of tissue, and it hence received very little ionizing radiation.

In the event of nuclear war, standing crops would be exposed to ionizing radiation from fallout containing both beta and gamma radiation in generally similar amounts. The study reported here is an investigation of the possible effects from the beta component.

Extensive literature exists on the effects of gamma radiation on plants in contrast to the very limited information available concerning the effects of beta exposure to plants.

It is widely accepted that the relative biological effectiveness (RBE) of beta to gamma doses is essentially unity[1] in the moderate and high beta energies found in fallout resulting from a nuclear detonation. This means that, when given ergs of energy are transferred to a fixed amount of tissue, deleterious effects will be the same whether the ionizing radiation is beta or gamma. In spite of this consideration, few predictions can be made of beta damage from gamma data, because of geometrical effects. The gamma exposure tends to be uniform

THE SIGNIFICANCE OF LONG-LIVED NUCLIDES AFTER A NUCLEAR WAR

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ABSTRACT

The radiation doses from the long-lived nuclides ^{90}Sr and ^{137}Cs, to which the surviving population might be exposed after a nuclear war, are considered using a new evaluation of the transfer of ^{90}Sr into food chains.

As an example, it is estimated that, in an area where the initial deposit of near-in fallout delivered 100 R/hr at 1 hr and there was subsequent worldwide fallout from 5000 Mt of fission, the dose commitment would be about 2 rads to the bone marrow of the population and 1 rad to the whole body. Worldwide fallout would be responsible for the major part of these doses.

It is now widely recognized that long-lived fission products would make a negligible contribution to the radiation exposure of the population in heavily contaminated areas shortly after a nuclear attack. The external radiation dose would usually be dominant, and, if simple precautions were taken to avoid the superficial contamination of foodstuffs, the entry of ^{131}I into milk would cause the only important problem of dietary contamination. Thus, for example, infants probably would not receive doses of more than 0.1 rad to bone marrow from ^{90}Sr nor more than 0.01 rad from ^{137}Cs in the weeks after a nuclear attack if they were fed continuously with milk produced in an area where the external dose rate at 1 hr after detonation had been 100 R/hr. Doses to the thyroid from ^{131}I might, however, exceed 200 rads.

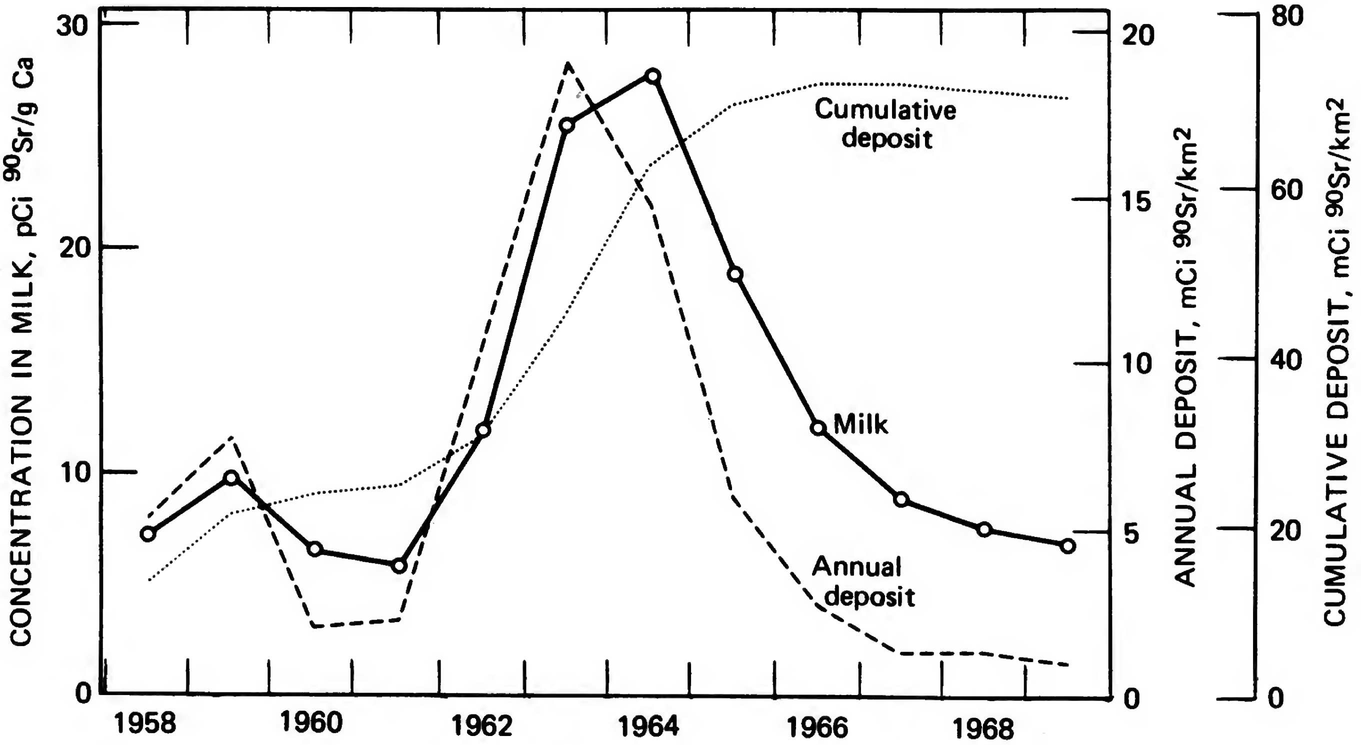

Fig. 1 Strontium-90 in fallout and milk in the United Kingdom, 1958 to 1969.

EFFECTS OF EXPOSURE TIME AND RATE

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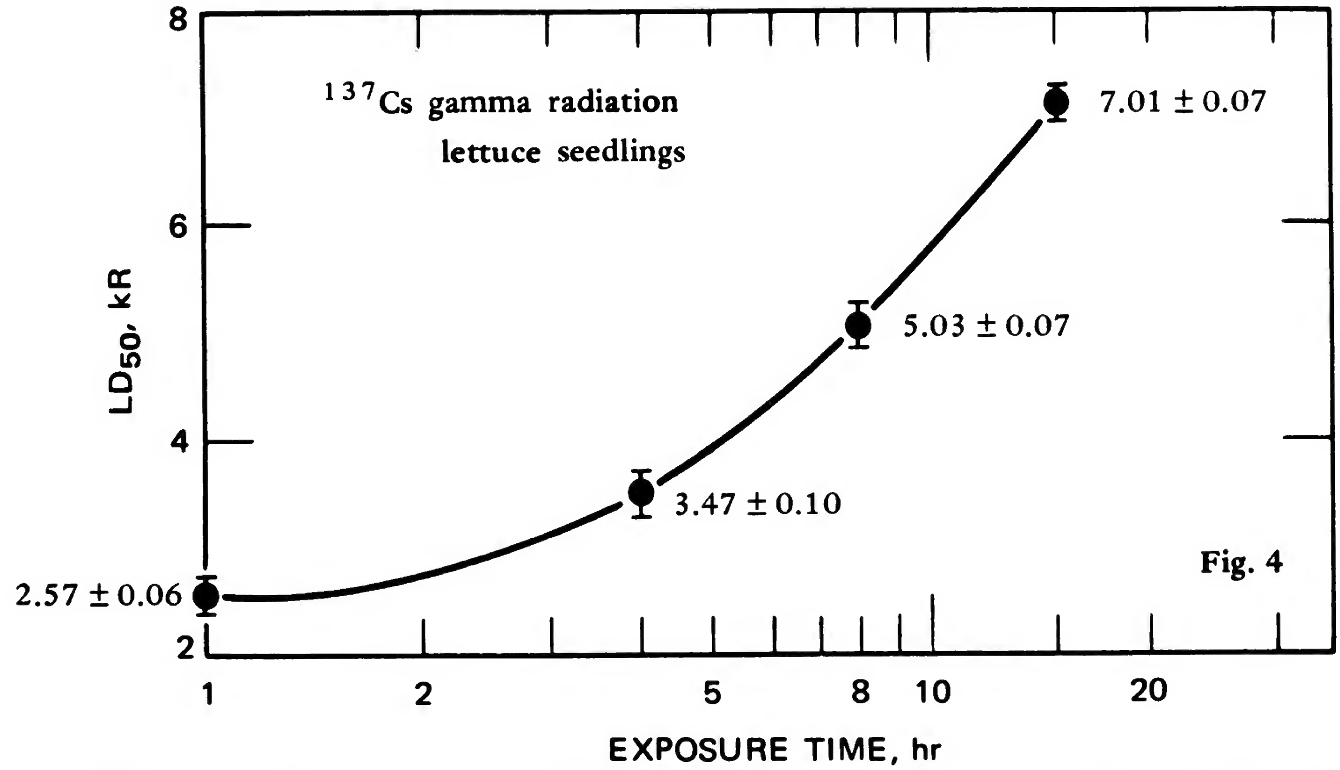


Fig. 4

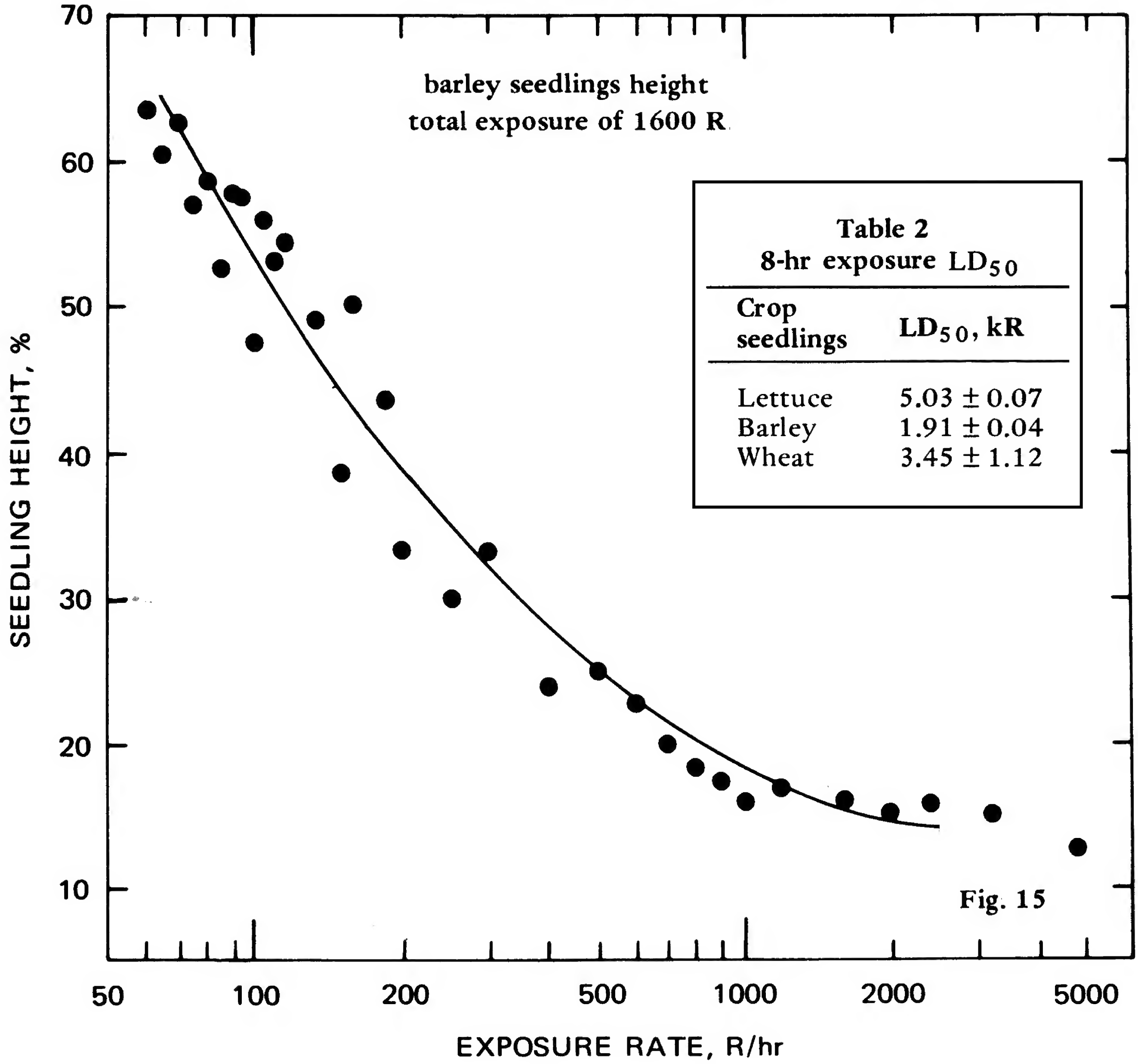
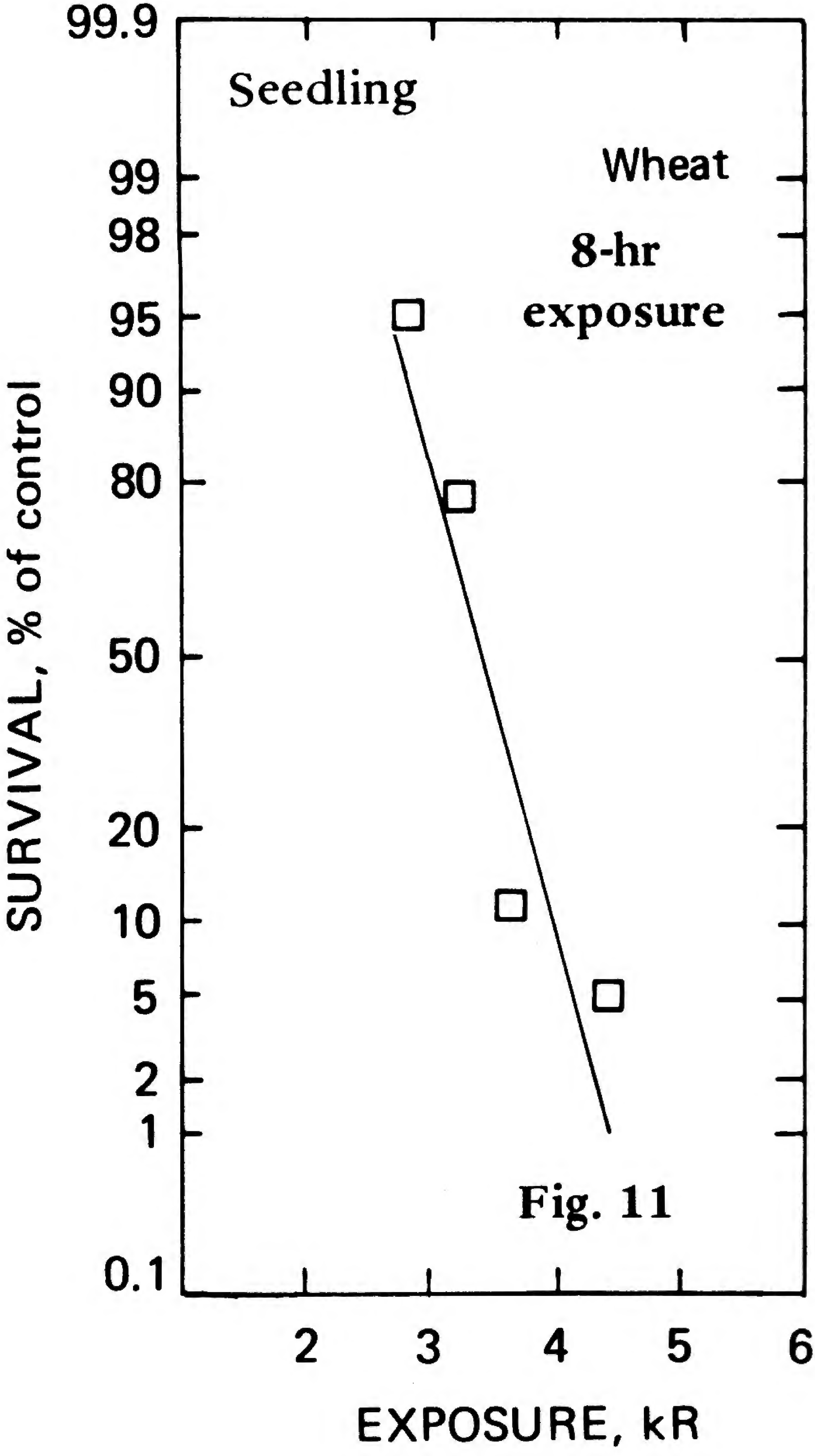


Table 2
8-hr exposure LD_{50}

Crop seedlings	LD_{50}, kR
Lettuce	5.03 ± 0.07
Barley	1.91 ± 0.04
Wheat	3.45 ± 1.12

Fig. 15


99.9
Seedling
Wheat
8-hr
exposure
99
98
95
90
80
50
20
10
5
2
1
0.1
SURVIVAL, % of control
2
3
4
5
6
EXPOSURE, kR
Fig. 11

THE EFFECTS OF EXTERNAL GAMMA RADIATION FROM RADIOACTIVE FALLOUT ON PLANTS, WITH SPECIAL REFERENCE TO CROP PRODUCTION

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Table 11

MISCELLANEOUS FRUITS AND VEGETABLES

Plant	Yield Reduction from unirradiated control		
	YD_{10} or LD_{10} ± S.D., R	YD_{50} or LD_{50} ± S.D., R	YD_{90} or LD_{90} ± S.D., R
Strawberry, 'Takane' Stolon 17 R/min	1,330 ± 650	6,530 ± 1860	20,800 ± 7300
Tomato, 'Rutgers' Seedling 16-hr exposure	10,100 ± 480	12,100 ± 290	17,600 ± 800

Table 12

PASTURE AND FORAGE CROPS 30 R/min 7-week seedling

Plant	Yield Reduction from unirradiated control		
	YD_{10} or LD_{10} ± S.D., R	YD_{50} or LD_{50} ± S.D., R	YD_{90} or LD_{90} ± S.D., R
Meadow fescue	1,500 ± 1070	2,480 ± 930	5,150 ± 1070
White clover	6,450 ± 370	23,400 ± 970	69,900† ± 3930

*Communicated by R. S. Russell, Agricultural Research Council, Letcombe Laboratory, England, 1970.

THE IMPORTANCE OF TRITIUM IN THE CIVIL-DEFENSE CONTEXT

pp. 71–80.

Table 3 shows that the internal tritium dose rate at 2 wks after burst is 10,000 times less than the external gamma fission product dose rate —

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ABSTRACT

The importance of tritium in the civil-defense context is assessed by comparing the dose rate and the 30-year dose integral for tritium from fusion with the external dose of gamma-emitting fission products.

The tritium dose is computed by assuming equilibration of fallout tritium with water in the biosphere and with the body water of man. The fission-product gamma dose for late-time dose-significant nuclides is tabulated in roentgens per hour per kiloton per square mile as a function of time.

Tritium is shown to be relatively unimportant in the civil-defense context when compared with the external gamma dose from an equal yield of fission products.

The survival of man in an environment contaminated with radioactive fallout after a nuclear attack is the basis on which the importance of tritium in the civil-defense context can be assessed. Although tritium is a weak beta emitter, the radiation hazard to man can be significant because of the high yield of residual tritium from fusion devices. Also, tritium is relatively mobile and, as tritiated water, becomes rapidly dispersed in the environment where it is available for ingestion by man. On the other hand, the hazard is reduced somewhat by the dilution of tritium with the large amount of water in the environment.

The importance of any single isotope can only be compared with respect to other radioisotopes produced in a nuclear explosion. As a first estimate, therefore, the radiation hazard to man from residual tritium is compared with that from fission-product radioactivity.

When certain reasonable assumptions are made, the dose rate as a function of time and the 30-year dose integral can be determined per unit area and unit

EFFECTS OF BETA-GAMMA RADIATION OF EARTHWORMS UNDER SIMULATED-FALLOUT CONDITIONS

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ABSTRACT

Experiments on ^{60}Co gamma and $^{90}Sr-^{90}Y$ beta radiosensitivity of *Lumbricus terrestris* and dosimetry models of soil systems were designed to study the effects of fallout radiation on natural earthworm populations. Epithelial tissues (skin and/or intestinal) were the primary sites for radiation damage. The $LD_{50/30 \text{ days}}$ for gamma was 67.8 krads; no significant increase in mortality occurred for beta irradiations up to 102.4 krads. In situ dosimetry models with ^{137}Cs show that beta radiation is important only for direct contact (because of soil shielding) and that gamma radiation typically would contribute from 68 to 100% of the external body dose of natural populations. Habitat shielding, high radioresistance of earthworms, and radioactive decay preceding particle incorporation into soil suggest minimal population mortality due to radiation from anticipated weapon yields.

The delivery of external radiation exposure dose to biological systems at specific locations in a fallout field is generally in the form of an acute or short-term damage phenomenon.[1] Because of the paucity of data on effects of beta dose on invertebrates,[2] the effects of beta and gamma radiation from nuclear fallout generally had been assumed to be comparable. Recent information on contaminated-particle retention by vegetation[3] and contact doses from beta radiation[4] suggests that areas of serious damage to organisms from fallout will be larger than previously estimated from gamma radiation alone.

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